Decomposition kinetics of aquatic macrophyte *scirpus cubensis* under the influence of dissolved phosphate levels

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Resumo

A dinâmica de ambientes lênticos tropicais colonizados por macrófitas aquáticas mostra-se grandemente influenciada pelos processos associados à sua decomposição. Nesse sentido, foram estudados aspectos relacionados à mineralização de *Scirpus cubensis* proveniente da lagoa do Infernão (SP, Brasil). Diferentes concentrações de fosfato foram adicionadas a câmaras de decomposição de *S. cubensis*, com o intuito de se avaliar seu efeito sobre esse processo. Observou-se a importação de fosfato da água para o detrito, sendo que o fosfato particulado aumentou proporcionalmente à elevação de seus teores na água. Ocorreu elevação do teor de nitrogênio orgânico particulado ao longo do tempo, após o período de lixiviação inicial. O aumento das taxas de mineralização verificado indica um incremento da eficiência do processo de decomposição relacionado à presença de fósforo dissolvido.

Abstract

The dynamics of lentic tropical environments colonized by aquatic macrophytes is largely influenced by the processes associated to its decomposition. In this sense, aspects related to the mineralization of Scirpus cubensis *of the Infernão lake (SP, Brazil) were studied. Different phosphate concentrations were added to decomposition chambers of* S. cubensis, *with the aim of evaluating its effect on this process. This kinetic assay showed a trend toward phosphate accumulation in the remaining detritus. This increase in the particulate phosphate was proportional to the increase of phosphate addition to the water fertilization of the chambers. There was an elevation of the organic particulate nitrogen level along the time, then leaching losses. The increase of mineralization rates indicated an increment of the efficiency of the decomposition process related to the presence of dissolved phosphorous.*

Key-words: *Decomposition; Aquatic Macrophyte; Phosphate; Humic Substances*

Introduction

Infernão lake, situated in the state of São Paulo (21°35'S, 47°51' W), is part of the pound complex in the flooding valley of Mogi-Guaçu river, that forms isolated meanders due to the typical process of erosion-sedimentation of meandric rivers that run in sedimentary plains. Its extension is small and it is mostly colonized by aquatic macrophytes, being *Scirpus cubensis* dominant. According to Nogueira (1989), this species influences the limnological characteristics and the nutrients cycling of the whole ecosystem.

Infernão lake is located within the area of the Jataí Ecological Station, that is still fairly preserved, in spite of the increase of agri-industrial activities and urban centers in the vicinity. Both superficial and groundwater pollution related to the presence of agrochemical substances (herbicides, insecticides, fertilizers, acaricides and fungicides) is a result from agricultural activities, silviculture, garbage from the sugar factories and alcohol distilleries operating in the neighborhood of the Mogi-Guaçu river (Santos & Mozeto, 1992).

The decomposition of aquatic macrophytes influences the chemistry of the waters and this process can also be regulated by several biotic and abiotic events, such as pH, oxygenation conditions, temperature, size and composition of microorganisms communities and the concentration of nutrients.

The nutrient levels in the water influence the nutrient levels in the living plants, and the loss rates of detritus mass (Carpenter & Adams, 1979). The bacteria, while mineralize the organic carbon of the substratum, assimilate dissolved nutrients in the water, enriching it. The complex formed by the detritus particles and the bacterial biomass is enriched by the nutrients, that will be used as food by the detritivorous organisms (Fenchel & Harrison, 1975).

Thus, it becomes important to investigate the possible consequences of the eutrophication process under decomposition in this ecosystem, once the decomposition rates act as regulator of the nutrients cycling playing a critical role in the ecosystem. This work is part of a series of experiments on the influence of the dissolved nutrients concentration in the decomposition process of the aquatic macrophyte *Scirpus cubensis* of Infernão lake.

Materials and Methods

Three series of aerobic decomposition chambers were developed, each one corresponding to a total phosphate level (0 - 0,069 - 0,276 g) all of them with the same total nitrate level (3,984 g). Each chamber contained 5 g of dry and macerated plant for each 0,5 L of Infernão lake water previously enriched. On each sampling day (0, 1, 2, 3, 5, 10, 15, 30 and 60 days), the water contained in one of the chambers of each series, was filtered (net of 0,4 mm). The filtrate was submitted to pH analyses, electric conductivity and temperature (potentiometric methods). The levels of dissolved humic substances were determined (Bianchini Jr., 1982), as well as organic nitrogen levels by the Kjeldahl method (Allen *et al.*, 1974) and phosphate levels by the ascorbic acid method (*In*: Lemos, 1995). The remaining particulate material was submitted to the analyses of organic N and phosphate according to the above-mentioned methodology. Biomass loss data were adjusted to the simple exponential model and the decomposition rates were calculated for the different experimental conditions with the equation:

$$Wt = Wo * e^{-kt}$$

where,

Wt = amount of remaining material in time t (mg);

Wo = initial amount of plant (mg);

k = mineralization coefficient (day^{-1});

t = time (day);

e = base of neperian logarithm.

Results and Discussion

The decomposition kinetics under influence of the phosphate indicated little difference among the several tested concentrations (Figure 1). The smallest values of remaining particulate organic material were obtained for the intermediary concentration of phosphorous (P_1=80.96%). Larger mineralization rates were found in the presence of this nutrient ($P_1 \rightarrow k = 1,25 \times 10^{-3}.day^{-1}$; $P_2 \rightarrow k = 1,20 \times 10^{-3}.day^{-1}$), demonstrating its influence in the increase of the rates. However, the comparison of these results with previous experiments (Lemos, *op cit*), demonstrated a smaller efficiency of the decomposition process resulting of the saturation effect in the decomposition chambers originated by the large amount of nutrients and organic material already existent.

The pH increased along the experiment in all decomposition chambers, unlike the conductivity, that decreased with the time (Figure 2). During most of the experiments, the pH was considered ideal for bacterial activity. Most bacteria only grow on the pH level between 4 and 9, while the optimum for most of the aquatic bacteria is the range 6,5 - 8,5 (Rheinheimer, 1974).

The decrease of the electric conductivity (Figure 2) can be associated to a larger consumption and to the precipitation or adsorption of the ions in solution. The low rates and the high values of the remaining particulate material are indicative of a smaller revenue of the decomposition and, therefore, of smaller ion liberation.

There were not important variations on temperature (Table 1) among the different tested conditions.

The inorganic phosphate (Figure 3) showed a trend of water uptake for the detritus in the chambers that suffered phosphate additions. In this sense, in the intermediary concentration (P_1), about 14 % of the inorganic phosphate was kept close to the detritus (precipitate or adsorbed) and in the largest concentration (P_2), about 10 % was immobilized in the inorganic form in

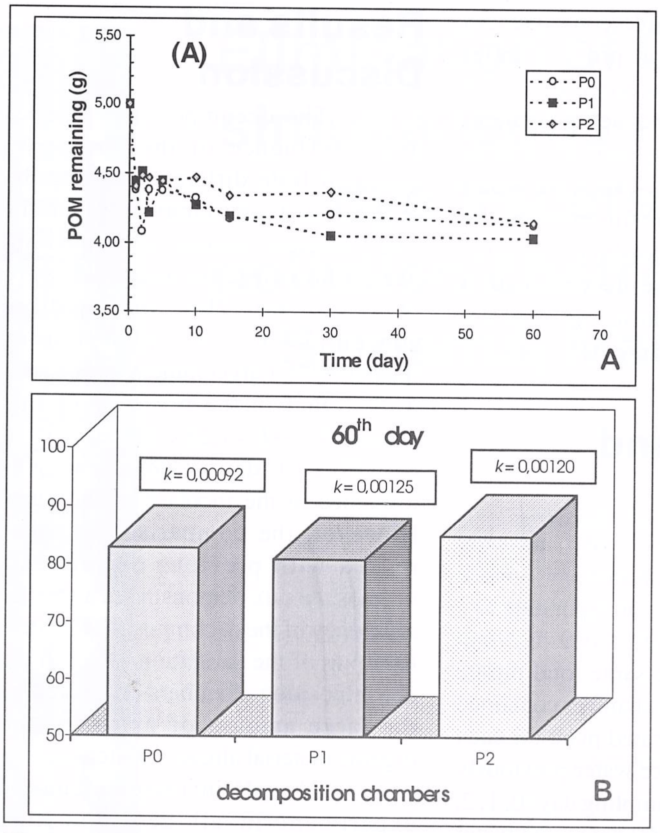

Figure 1 - Temporal dynamics of remaining particulate organic material (A) and percentage of remaining POM to the end of the assay (B) with the mineralization rates (day $^{-1}$) in the different treatments with phosphate.

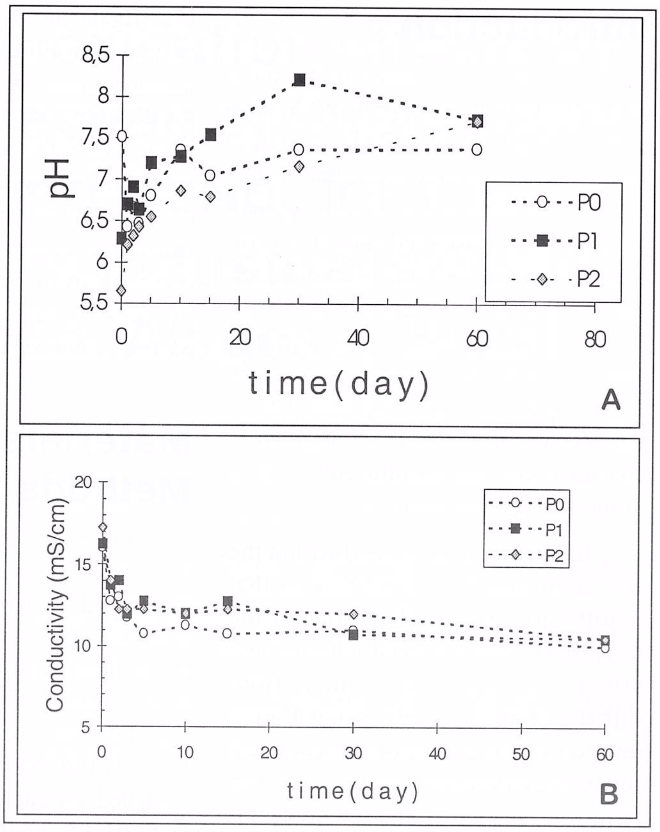

Figure 2 - pH (A) and electric conductivity (B) of the water during decomposition of *S. cubensis* under different levels of dissolved phosphate.

Table 1 - Averages and standard deviation (SD) of the water temperature during the decomposition kinetics assay.

	TEMPERATURE (° C)		
	P_0	P_1	P_2
average	25.89	24.94	25.94
SD	1.19	0.68	1.21

the detritus. The remains of the dissolved phosphate was probably immobilized in the organic form throughout the microbial uptake. On the other hand, the control showed liberation of inorganic phosphate. The phosphate added in the water increased the trend to the phosphorous immobilization in the detritus, in the inorganic or in the organic forms. The increase of inorganic phosphate in the detritus was proportional to the elevation of its levels in the water, suggesting that the inorganic phosphorous precipitated and/or adsorbed in the detritus was as large as the highest level of this dissolved nutrient.

The production of humic substances increased along the time (Figure 4) reaching very similar values among the different treatments. However, previous experiments (Lemos, *op cit*), indicated a larger influence of the nitrogen on the humification process than the phosphorous.

The levels of dissolved organic nitrogen (Figure 5) suffered an increase followed by a decline and the particulate organic nitrogen, after leaching, suffered an increase followed by a stabilization phase. This behavior can be associated to modifications in the dynamics of the microbial populations that colonize the liquid phase and the detritus itself, and secondarily, to the precipitation of acid humic on the detritus.

According to Cruz and Gabriel (1974), the increase of nitrogen and phosphorous observed during the decomposition, of fragments of *Juncus roemerianus* were, presumably, due to the microbial action and to the particulate nitrogen and phosphorous adsorbed to/or impregnated in the vegetable tissues in decomposition. Davis and Van der Valk (1983) attributed increases in the content of N and P in the litter in decomposition of *Typha glauca* to the consumption of these dissolved nutrients by the microorganisms.

Conclusions

The presence of the phosphate stimulated the decomposition process of the organic material of *Scirpus cubensis*, what was evidenced by the increase of the mineralization rates observed in the kinetic experiment. The electric conductivity was influenced by the leaching process and oxidation of the organic matter, by the consumption and immobilization of the dissolved substances, as well as the

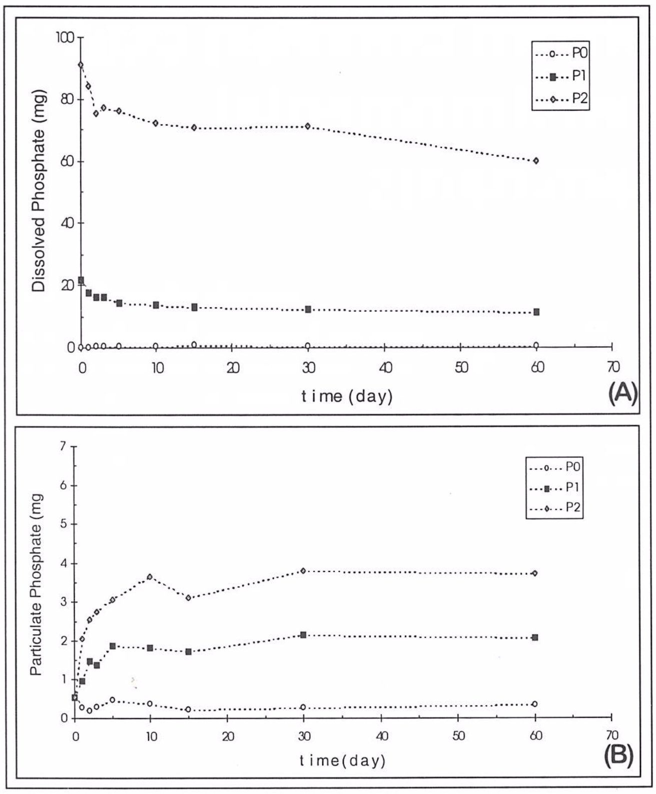

Figure 3 - Temporal dynamics of the dissolved (A) and particulate (B) phosphate during the decomposition of *S. cubensis* under influence of the different levels of dissolved phosphate.

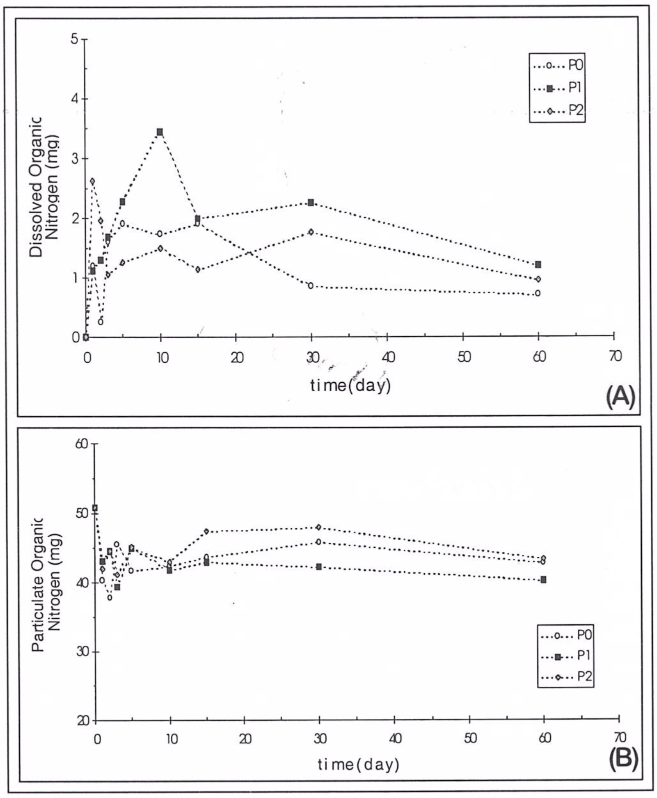

Figure 4 - Temporal dynamics of the dissolved (A) and particulate (B) organic nitrogen during the decomposition of *S. cubensis* under influence of the different levels of dissolved phosphate.

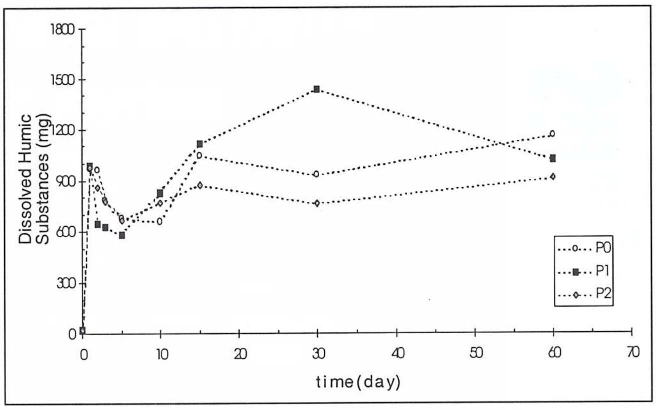

Figure 5 - Temporal dynamics of the dissolved humic substances during the decomposition of *S. cubensis* under influence of the different levels of dissolved phosphate.

conditions created by artificial fertilization of the medium and oxygenation of the chambers. There was a trend of the accumulation of nutrients in the detritus and the phosphate accumulation was clearly influenced by the concentration of dissolved phosphate.

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Sumário